

The flora and vegetation of Barrow Island, Western Australia

by R. C. Buckley

Dept Biogeography and Geomorphology, ANU, Canberra, ACT.*

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Abstract

Barrow Island is a limestone island 233 km² in area off the northwest coast of Western Australia. Its flora comprises both coastal and arid elements. Undisturbed vegetation may be classified into the following main types, listed in decreasing order of areal extent: *Triodia wiseana* hummock grassland on limestone uplands; *Triodia angusta* hummock grassland on watercourses and lowland loams; *Triodia pungens* hummock grassland on red sand; coastal complex, primarily *Spinifex longifolius* assemblage on white calcareous foredunes; short forb community on floodout flats; salt flat; and mangroves. These are mapped and described, a total of 29 subtypes being recognised. Vegetation patterns in undisturbed areas are controlled primarily by substrate, but fire, grazing and exposure to salt-laden winds are also involved.

Introduction

Barrow Island is a limestone island approximately 29 km by 11 km, 56 km from the West Australian coast between Onslow and Port Hedland (Fig. 1). Its vegetation is of significance for the following reasons. Firstly, it contains substantial areas of arid calcicole *Triodia* hummock grassland. There are detailed analyses of arid hummock grassland on inland siliceous sands (e.g. Wiedemann 1970, Fatehen and Barker 1979, Buckley 1981) but only broad descriptions of those on coastal calcareous sands (e.g. Sauer 1965, Burbidge 1971, Beard 1975). Secondly, Barrow Island is a Class A Reserve, and a knowledge of vegetation pattern is therefore significant for fauna conservation. Thirdly, Barrow Island was cut off from the mainland by rising sea-levels about 8 000 years ago. Are there endemic Barrow Island races of plant species as there are for some of the animals?

Lying at 115° 20' E, 20° 45' S, off the north-west shoulder of Western Australia, Barrow Island experiences a monsoonal northern climate (Gentilli 1972) moderated by its oceanic position. Prevailing winds are predominantly easterly in summer and south-westerly in winter. Summer temperature maxima exceed 40°C whilst winter maxima approximate 26°C. Mean annual rainfall is 200 mm, with peaks in February-March and May-June. Cyclones may occur between November and March; one in March 1964 deposited 330 mm rain in 12 hours (Butler and Cox 1975). Creeks and claypans fill only during the wet season. Heavy dews are also common.

The island consists of Tertiary limestones—the Upper Eocene Giralia Calcarene and the lower Miocene Trealla Limestone—overlain by Quaternary dune limestone, alluvium and coastal sand (Kriewaldt 1964, Parry 1967). The Tertiary rocks are folded

into an anticline. The southern end of the island is low as a result of faulting (the Barrow Island Fault), and the northern end as a result of the northern plunge of the anticline, together with minor faulting. The central section is wedge-shaped in cross-section, sloping from high coastal cliffs and steeply dissected uplands in the west to low cliffs and coastal plains in the east. The subsurface geology was outlined by Crank (1973).

Previous studies of Barrow Island vegetation may be summarised as follows. Serventy and Marshall (1964) noted *Triodia* hummock grassland as the dominant vegetation and listed 34 plant species during a zoological survey in 1958. Goodall (1969) constructed partial distribution maps in 1964 for 93 named species; Burbidge and Main (1971), reporting on a visit in 1969, collected 32 plant species and described the vegetation only as "tussock grassland dominated by *Triodia*", as did Main and Yadav (1971). Butler (1970) recognised 6 zones or habitat types, summarised in Table 1, with stands of *Erythrina vespertilio* and *Eucalyptus patellaris* as subtypes. This classification was used by Beard (1975) and Sedgwick (1978). Sedgwick and Butler also made brief descriptions of the vegetation at 80 points on the island, each located randomly within a 3 km grid square (Sedgwick 1976, Appendix E).

Table 1

Summary of previous vegetation classification (Butler 1970)

No.	Zone	Substrate	Characteristic species
1	Foredune	white sand	<i>Spinifex longifolius</i>
2	Red dunes	red sand	<i>Triodia angusta</i> , <i>Acacia coriacea</i>
3	Ridges	limestone	<i>Triodia wiseana</i>
4	Pans	clay	<i>Paspalum tabulatum</i>
5	Creekbeds	red earths	<i>Triodia angusta</i>
6	Mangrove	tidal muds	<i>Avicennia marina</i>

* Present address: ASPECT consultant Group, P.O. Box 114, Eastwood, SA 5063.



Figure 1.—Distribution of main vegetation units described in text.

Analysis of vegetation pattern in a large and relatively complex area such as Barrow Island must proceed in a series of successive approximations (Poore 1962). A single numerical analysis of vegetation data from random or blocked-random sample sites, for example, can only reveal the broader patterns (Buckley 1983). More precise descriptions require further analyses, with sampling patterns based on the results of previous approximations. I therefore used the classification given in Table 1 as a first approximation or first-degree classification. My aims were as follows. Firstly, I tested the validity of the first-degree classification by examining floristic separation between its 6 units. Secondly, I attempted to refine it to a second-degree classification. Thirdly, I mapped the distribution of the major units. Fourthly, I examined the relations between vegetation and factors such as soils, fauna and fire regime, in so far as time permitted, and attempted to pinpoint problems deserving investigation in the future.

Methods

1. Tests of first-degree classification. Firstly, I compiled floristic censuses for ten 1 m x 1 m, ten 5 m x 5 m and five 25 m x 25 m quadrats in each of units 1-5 as listed in Table 1, plus the *Erythrina vesperitilo* subunit and a *Halosarcia* salt flat, and compared the overall floristic assemblage and the species-area relations in each unit to test floristic separation between units. Secondly, I analysed vegetation changes across the boundaries between the units, by laying out transects of contiguous 5 m x 5 m quadrats perpendicular to the boundaries, and scoring the presence or absence of each species in each quadrat. The resulting matrices were clustered by unconstrained hierarchical polythetic agglomeration and monothetic division, using the error sum of squares and euclidean distance in each case, followed by relocation, and the characteristic species of each cluster identified from their binary frequency ratios.

2. Second-degree classification. Using results from the above, I constructed a second-degree classification subjectively.

3. Vegetation mapping. The distributions of the major vegetation units were mapped from 1:20 000 vertical colour aerial photographs and a colour photo-mosaic of the entire island and 1:10 000 false-colour infrared vertical air photocoverage of selected portions, supported by extensive ground survey. The distributions of shrubs restricted to limited regions of the *Triodia wiseana* limestone upland vegetation were also mapped by ground survey.

4. Relation to environment. Soil texture was assessed subjectively in the field. Soil fertility was assessed by taking soil samples at intervals along transect lines, and from bulldozed pits where available, and measuring their pH, salinity, total N (micro-Kjeldahl method), and extractable P (1% bicarbonate extract). Other factors were assessed from historical records (e.g. fires), or subjectively (e.g. exposure, guano input).

Results

Flora

A complete floristic list is given in Appendix 1, which also shows the main habitat of each species using the first-degree classification given in Table 1. It comprises 218 species supported by voucher specimens, and a further 39 species mentioned in previous published or unpublished reports but no longer traceable to voucher specimens.

Transects

Profiles and cluster diagrams for the five transects are given in Figs 2 and 3. Cluster groups produced by monothetic division were similar or identical to those produced by polythetic agglomeration. Dendrograms are not reproduced here but are available from the author on request.

Transect 1 was taken across a valley cut by a deep river bed, its ends being in *Triodia wiseana* on limestone ridges, and its centre in *T. angusta* on deeper valley soils (Fig. 2). The two main clusters coincide with the *T. wiseana* and *T. angusta* areas as recognised on the ground, verifying that different floristic assemblages are associated with the two different *Triodia* species and that terrain classification on the basis of the dominant *Triodia* species represents a classification into recognisable and distinct plant communities. The characteristic species of the *T. wiseana* assemblage are: *Diplopeltis eriocarpa*, *Dodonaea lanceolata*, *Scaevola cunninghamii*, *Codonocarpus cotinifolius*, *Petalostyles labicheoides*, *Hannafordia quadrivalvis*, and *Acacia gregorii*. Only the first two of these are entirely confined to the *T. wiseana* quadrats, but all are relatively abundant, so that their greater frequency in the *T. wiseana* cluster has very high statistical significance, measured from the hypergeometric distribution as described by Buckley (1981).

Many of the species characterising the *T. angusta* assemblage grew only in the centre of the valley, and despite being quite abundant there, were consequently recorded in only one or two quadrats of the transect: namely, *Adriana tomentosa*, *Indigofera monophylla*, *Pterigeron hubakii*, *Solanum lasiophyllum*, *Dysphania plantaginella* and *Paspalidium tabulatum*. Three further species, *Centipeda minima*, *Cymbopogon procerns* and *Tephrosia rosea*, were also confined to the *T. angusta* assemblage; they were recorded in 5, 4 and 3 quadrats respectively. The other characteristic species of the *T. angusta* assemblage were *Stylobasium spathulatum*, *Calandrina balonensis* and *Chrysogonum trichodesmoides*.

The third cluster shown for this transect comprises quadrats associated with the road verge, the river bed, and old tracks along the southern side of the valley. Six species have high binary frequency ratios in this cluster: *Chamaesyce atoto*, *Trichodesma zeylanicum*, *Acanthocarpus preissii*, *Corchorus sidioides*, *Hannafordia quadrivalvis* and *Stylobasium spathulatum*. Of these six, the first two species are representative of disturbed ground only, whilst the next three are also common on the limestone slopes, and the last on the valley soils. Further division separates

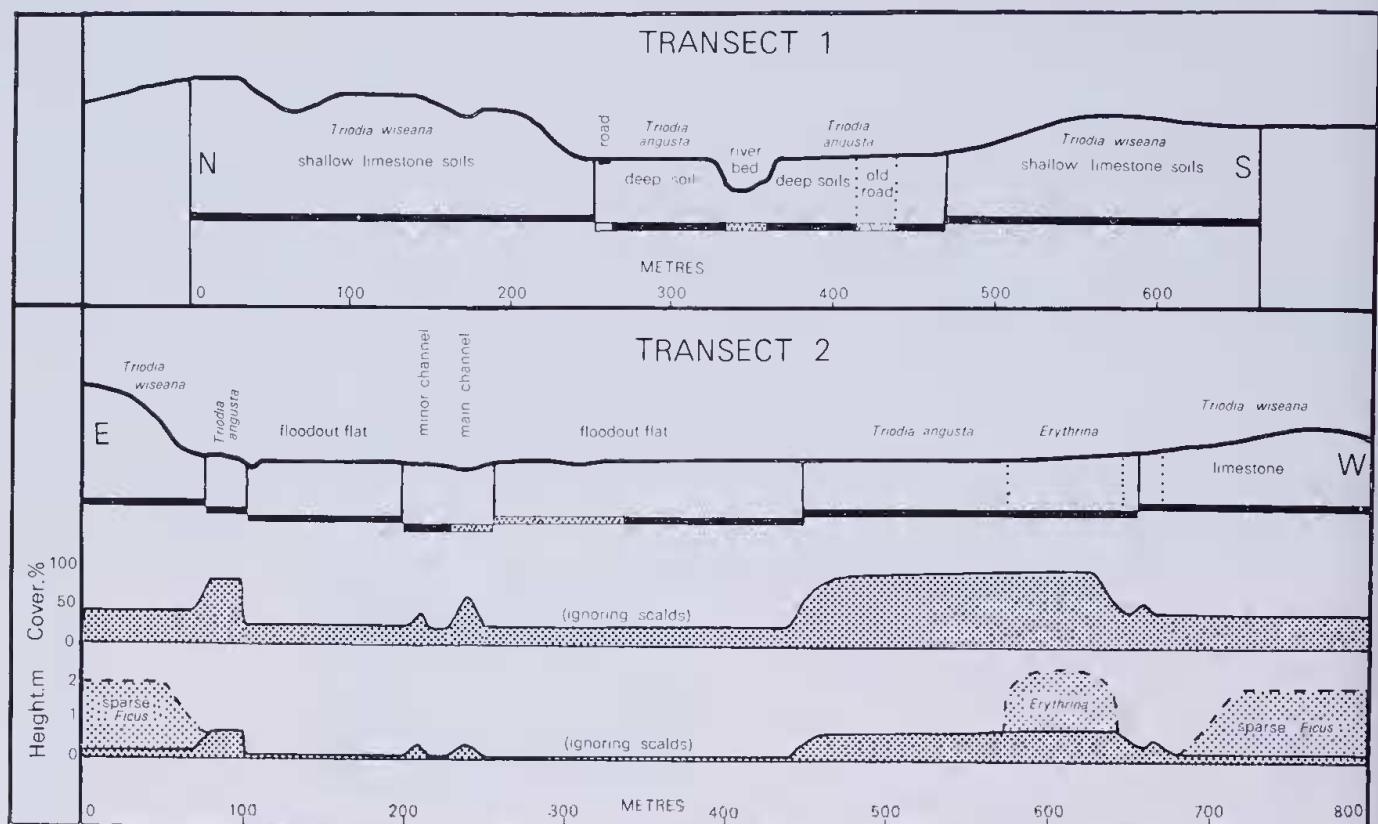


Figure 2.—Vegetation transects 1 and 2. Approximate topographic profiles are shown as heavy lines. Floristic clusters (see text) are plotted as horizontal bars, each cluster on a different horizontal line. Shaded areas within bars represent subdivisions of main clusters. Thus in transect 1 the *Triodia angusta* valley cluster is comprised of three sub-groups occupying respectively the deep valley soils, the riverbed, and ground disturbed by tracks. In transect 2, the western half of the floodout-flat cluster is subdivided at the next finer stage, as is the central-channel cluster. Total aerial cover and vegetation cover are also shown for transect 2, with the ground and shrub layer distinguished by shading density in the latter case. Cover and height are not shown for transect 1 since both main clusters are hummock grassland of closely comparable structure.

the *T. wiseana* cluster into a mosaic of three sub-units, associated only indistinctly with small-scale topography. At the boundaries between the *Triodia angusta* and *T. wiseana* zones there are regions where both occur together. These are grouped with the *T. angusta* quadrats on the basis of overall floristics: 97% of quadrats containing *T. angusta* (with or without *T. wiseana*) are in the *T. angusta* cluster, the corresponding figure for *T. wiseana* being only 77%; 95% of the 'mixed' quadrats are grouped with *T. angusta*.

The second transect runs across the largest floodout flat on the island, starting on a ridge on its inland side (Fig. 2). Clusters based on overall floristics coincide very precisely with vegetation types recognised on the ground. Limestone hills at the eastern and western ends bear low open *Triodia wiseana* hummock grassland, and the flat is fringed by a band of very dense *T. angusta*, accompanied on the western margin by *Erythrina vespertilio*. The boundary between the *T. wiseana* and *T. angusta* is much sharper than in transect 1. A flood channel runs down the centre of the flat; where crossed by the transect, it consists of a shallow eastern section and a deeper western channel. Immediately bare area of the flood channel there is a relatively bare area of flat with numerous scalds. All these features are reflected in the cluster groupings in Fig. 3. Seven species are confined to the *T. wiseana* community: *Polycarpaea longiflora*,

Caladrinia halonensis, *Indigofera colutea*, *Ficus platypoda*, *F. opposita*, *Enneapogon oblongus* and *Chamaesyce australis*. *Paspalidium tabulatum* and *Ptilotus obovatus* are also common between spinifex hummocks. *Abutilon exouenum* and *Capparis spinosa* are common in both *T. wiseana* and *T. angusta* but not on the flat; *Chrysopogon fallax* and *Eulalia fulva* protrude from the *T. angusta* hummocks, though not present in the transect. The floodout flat bears an assemblage of small forbs, notably *Heliotropium undulatum*, *Stackhousia elata*, *Sida fibulifera*, *Sporobolus australasicus*, *Centipeda miniua*, *Centaureium erythraea*, *Chamaesyce atoto*, *Dichanthium affine*, *Dysphania plantaginella*, *Eragrostis xerophila* and *Haloragis gossei*. Scalded areas are more depauperate, *Pterigeron bubakii*, *Eragrostis xerophila* and *Centaureium erythraea* being the main species; the central flood channels support a lush growth of the forbs mentioned above, together with *Pterocaulon sphacelatum*, *Morgania glabra*, *Malvastrum spicatum*, *Cleome viscosa*, *Triumfetta leptacantha* and *Trichodesma zeylanicum*, some of these being more common in the eastern channel and others in the western.

Half of the hummocks in the easternmost fringe of the western *T. angusta* belt were dead in September 1980, and a quarter of those in the centre of the belt; this might have been the result of flooding, but since most of the remaining hummocks had brown centres under thin green skins it could indicate

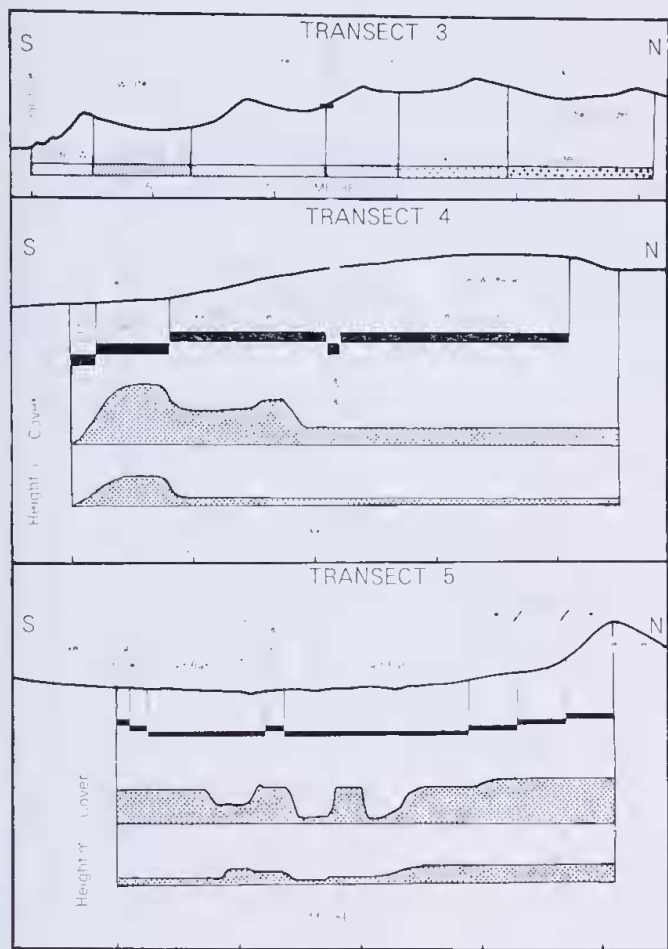


Figure 3.—Vegetation transects 3, 4 and 5. Key as for Figure 2. The vegetation of Transect 3 is much more uniform than that of the other 4 transects; it can be subdivided satisfactorily, but at a lower dissimilarity level. The 6 clusters represent sections of a continuous gradient within a single main vegetation type, rather than the sharply demarcated communities characteristic of the other transects, and have therefore been shown as subdivisions of a single bar.

that the stand was overmature. The ground under the trees was bare save for occasional seedlings of *Triodia* and *Abutilon exoniense*, abundant *Erythrina* seedlings 10-40 cm high, and an open cover of *Malvastrum spicatum*, *Nicotiana occidentalis*, *Eragrostis xerophila*, *Trichodesma zeylanicum*, *Cleome viscosa*, *Haloragis gossei*, and *Pterigeron bubakii*, which were otherwise restricted to the sparse inter-hummock spaces.

The third and fourth transects contrast sandy and rocky coasts at the southern end of the island. Transect 3 runs from a sandy strandline and associated *Spinifex longifolius* on the white-sand foredune ridge, across an area of coastal *Acacia coriacea* on cream calcareous dunes a few metres high, to the edge of *Triodia pungens* hummock grassland on gently undulating subcoastal pink calcareous sands (Fig. 3). Structure being determined by the dominant species, the primary field classification is into *Spinifex*, *A. coriacea* and *T. pungens* zones. The vegetation of this transect is much more homogenous than that of the other 4, and if the same dissimilarity coefficient is used as a stopping value in the clustering process, the entire

transect would be included in a single cluster. The cluster dendrogram showed a gradual floristic change along the transect, however, and the *A. coriacea* zone can be subdivided on the basis of overall floristics, with distinct and non-overlapping quadrat groups on each ridge. This gradual floristic change may reflect the sequence of ridge soils: inspection of the raw data and binary frequency ratios indicates that floristic differences between them are confined to a gradual increase in species richness on the ridges further inland, with the sequential appearance of *Rhagodia obovata*, *Triodia angusta*, *Heliotropium undulatum*, *Adriana tomentosa*, *Chamaesyce myrtoides*, *Olearia axillaris*, *Nicotiana occidentalis*, *Dysphania plantaginella* and *Triodia pungens*. The fusion dendrogram indicates that these four groups are very similar floristically; the inland *T. pungens* zone is distinct though not disjunct floristically, whilst the strandline assemblage has the greatest floristic separation from the rest of the transect. *Spinifex longifolius* and *Atriplex semilunaris* are restricted to quadrats on the seaward side of the first ridge, also characterised by the loose-sand species *Ptilotus villosiflorus* and *Chamaesyce australis*, and the halophyte *Fraukenia pauciflora*.

Transect 4 commences on a narrow beach of limestone pebbles and runs through a narrow band of *Spinifex* on shallow sand, a tall dense belt of *Triodia angusta* with *Stylobasium spathulatum* and *Acacia bivenosa*, and up a short slope, covered by low open *Triodia pungens*, to a limestone ridge bearing a mixed *T. wiseana*-*T. pungens* assemblage (Fig. 3). The limestone cap and slopes are floristically similar, the main difference being the presence of *T. wiseana* on the cap only. Rather than separating slopes and cap, further division into four clusters picks out the two quadrats at the edge of the cap; these lack *T. pungens* and most of the associated species, instead containing *Dodonaea lanceolata*, *Capparis spinosa*, *Rhynchosia minima* and *Boerhaavia diffusa*. Two relatively abundant species, *Diplopeltis eriocarpa* and *Nicotiana occidentalis*, are confined to the *T. wiseana*-*T. pungens* assemblage on limestone, as are six further species, notably *Jasminum calcareum*, *Ficus platypoda* and *Chenopodium carinatum*. *Olearia axillaris*, *Fraukenia pauciflora* and *Stylobasium spathulatum* are confined to the *Triodia angusta* belt, which is also characterised by *Acacia bivenosa* and *Myoporum acuminatum*. *Rhagodia obovata* is the main species associated with *Spinifex longifolius* in this transect, whilst *Enchylaena tomentosa* and *Ptilotus villosiflorus* are also common on the rubble beach itself.

The fifth transect crosses a salt flat near the northeastern coast. The flat lies between two limestone ridges, and the transect starts at the base of the southern ridge, close to the edge of the flat, and continues to the top of the northern ridge (Fig. 2). Four clusters are separated: the *Triodia wiseana* community on the limestone ridges; a mixed *Triodia* assemblage on the lower limestone flanks; a "fringe" group comprising quadrats at the edges of the salt flat together with a few on a slightly raised limestone area within it; and the main saltflat community, comprising 60% of the total. The

Triodia wiseana community is characterised, as elsewhere, by *Polycarpaea longiflora*, *Heliotropium ovalifolium*, *Cymbopogon procerus*, *Pterocaulon sphacelatum* and *Solanum lasiophyllum*. *Scaevola cunninghamii*, *Ficus platypoda* and *Sida corrugata*, each recorded only once, are also confined to the ridges. The mixed *Triodia* assemblage, besides containing all three *Triodia* spp., is characterised by *Cymbopogon procerus*, *Trichodesma zeylanicum*, and *Sclerolaena spinosa*; the "fringe" quadrats lack *T. wiseana* and are characterised by *Sclerolaena spinosa* and *Nicotiana occidentalis*. On the main salt flat *Sclerolaena* is replaced by *Neobassia astrocarpa*, *Frankenia pauciflora*, *Threlkeldia diffusa* and *Linonium salicorniaceum*. In addition, there is a consistent microtopographic pattern, with the succulent halophytes *Halosarcia halocnemoides* and *H. indica* ssp. *leiostachya* in slight salty depressions, and *Sporobolus virginicus*, *Dysphania plantaginella* and *Synaptantha tillaeacea* on slightly higher areas.

Results of the transect analyses may therefore be summarised as follows. Transect 1 demonstrates that the distinction between *Triodia wiseana* and *T. angusta* vegetation types is supported by overall floristic differences. Comparison of transects 1, 2, 4 and 5 shows that there is a variety of mixed-*Triodia* assemblages with a variety of associated species, which cannot satisfactorily be included with any of the single-*Triodia* communities. Transect 2 again confirms the *T. wiseana*-*T. angusta* separation and demonstrates that the floodout forb-flat is floristically as well as structurally distinct from the hummock grasslands. It also shows that the *Erythrina* woodland is not a separate community, but merely a hummock grassland with *Erythrina* overstorey. The third and fourth transects contrast vegetation pattern on white-sand and limestone-rubble coastlines, and the fifth describes a distinct salt flat assemblage.

Overall, the transects demonstrate clear floristic separation between the units of the first-degree classification, which is therefore supported. There is floristic overlap between the mixed *Triodia* assemblages and the three single-*Triodia* communities; between the understorey of old *Avicennia* stands on sand, and the salt-flat assemblage; between the assemblages of coastal and inland limestone; and between disturbed ground and surrounding undisturbed vegetation.

Maps.

The main vegetation units are mapped in Fig. 1. The subunits are not mapped. Coastal and sub-coastal sand assemblages (*Spinifex longifolius*, *Acacia coriacea*, coastal *Triodia angusta* and *T. pungens*) are mapped as a single unit owing to constraints of scale. Within the *T. wiseana* limestone uplands, a number of shrub species are confined to particular regions. A similar situation applies in the *T. angusta* lowlands. The distributions of 10 such species are mapped in Figs. 4 and 5. The distributions of *Hakea suberea* and *Gossypium robinsonii* were also mapped; both are scattered but widespread and have therefore not been shown here.



Figure 4.—Distribution of *Acacia pyrifolia*, *Cassia pruinosa*, *Codonocarpus cotinifolius*, *Eucalyptus patellaris*, *Melaleuca cardiophylla* and *Passiflora foetida*.



Figure 5.—Distribution of *Acacia victoriae*, *Erythrina vespertilio*, *Grevillea pyramidalis* and *Santalum lanceolatum*.

Second-degree classification.

I propose the following second-degree classification:

1. Limestone uplands dominated by *Triodia wiseana*

(a) higher ridges and plateaux with caprock, in centre and west of island. Open *T. wiseana* cover, 0.3 m high. Associated species: *Ficus platypoda*, *Pittosporum phylliracoides*, *Acacia pyrifolia* (Fig. 4), *A. gregorii*, *Enneapogon oblongus*.

(b) lower ridges and slopes, with limestone rubble. *Ficus platypoda*, *Codonocarpus cotinifolius*, *Grevillea pyramidalis*, *Cassia pruinosa*, *Pittosporum phylliracoides*, *Melaleuca cardiophylla* in certain areas (Fig. 4). *Indigofera monophylla*, *Diplopeltis eriocarpa*, *Corchorus sidioides*, *C. parviflorus* and *Polycarpha longiflora* often associated.

(c) steep gullies with *Mallotus nesophilus* and *Goodenia microptera* in patches (centre and west); limestone solution hollows with *Mallotus*, *Cyperus cunninghamii*, *Plumbago zeylanica* and *Nicotiana occidentalis*.

(d) *Eucalyptus patellaris* stands. One of these is in a creekbed ("Valley of the Giants") and the other on a high western ridge (Figs 1, 5).

2. Areas dominated by *Triodia angusta*: watercourses and lowlands

a. watercourse lines in upland areas, bearing narrow lines of *T. angusta* cutting through the *T. wiseana* on slopes and ridges.

b. broad areas of dense *T. angusta* on flat bottoms of main valleys, on deep soils derived from slope-wash debris. Clumps to 1 m height x 2 m diameter, 70-90% cover. *Gossypium robinsonii* often associated.

c. extensive lowland plains to east and south of island (Fig. 1), characterised by an *Acacia bivenosa* overstorey.

d. subcoastal fringe in some areas (e.g. south coast) where a belt of *T. angusta*, often with intermittent *Acacia coriacea* overstorey, lies between coastal *Spinifex* and a belt of *Triodia pungens* slightly further inland.

e. *T. angusta* with *Erythrina vespertilio* overstorey; a number of small stands (Fig. 5).

f. *T. angusta* with *Acacia victoriae* overstorey; a single stand on old red sands associated with fossil shells of the bivalve mollusc *Anadara* (Fig. 5).

3. Mixed *Triodia* assemblages

These do not form ecologically separate units, but are either ecotonal, in the case of (a) and (b), or in the case of (c) a mosaic controlled by small-scale soil pattern. They are listed together for convenience only.

(a) cemented conglomerate (old valley fill) at margins of present valleys. Dense *T. wiseana* with some *T. angusta*.

(b) similar areas but with less cemented or deeper soils; *T. angusta* stands with isolated *T. wiseana*.

(c) a large area of *T. pungens* / *T. angusta* / *T. wiseana* mosaic in the northeast corner of the island (Fig. 1). *T. wiseana* is confined to ridges, and is more abundant toward the western side of this region. Coastal sandy areas bear *T. angusta*, as do watercourses; the intervening red sands or blown red sands on limestone carry *T. pungens*.

4. Coastal sand assemblages

a. strandline: *Ipomoea pescaprae*, *Salsola kali*.

b. white aeolian foredune areas: open vegetation dominated by *Spinifex longifolius* and also characterised by *Ptilotus villosiflorus* and *Cynanchum floricundum*.

c. *Acacia coriacea*-*Triodia angusta* belt on cream to pink sands behind *Spinifex* zone, on the inland sides of the white-sand foredunes. *A. coriacea* also grows in association with *Spinifex* (assemblage b) and *T. pungens* (assemblage d) but less densely and consistently.

d. *Triodia pungens* on red sands inland from foredunes. This includes low red dunes, often with *A. coriacea* overstorey, and narrow red sand flats inland. This community is also characterised by *Scaevola cunninghamii*.

5. Coastal rock assemblages

a. limestone or conglomerate cliffs, scarps and headlands bearing *Triodia wiseana*, and also characterised by *Sarcostemma australe* and *Capparis spinosa*.

b. exposed cliffs to the southwest, covered with blown sand and bearing *T. angusta* and *Frankenia pauciflora*.

c. exposed headlands and visors; bare or with sparse *Frankenia* cover.

d. conglomerate—pebble beaches (e.g. the northern margin of Bandicoot Bay) with a narrow strandline zone of *Frankenia pauciflora* and *Spinifex longifolius* backed by *Acacia bivenosa* and *Stylobasium spathulatum* over *Triodia angusta*.

e. low limestone areas bearing *Frankenia*, *Sclerolaena*, *Neobassia* and *Halosarcia* species.

6. Mangroves: *Avicennia marina*

a. pure stands of *Avicennia* in mud pockets in limestone and rocky beaches.

b. Old *Avicennia* stands swamped by sand, with ground cover of halophytes toward inland margin: *Neobassia astrocarpa*, *Sclerolaena spinosa*, *Halosarcia* spp., *Frankenia pauciflora*, *Threlkeldia diffusa*, *Enchylaena tomentosa* and *Sporobolus virginicus*.

7. Floodout flats

Red sands, red clayey sands and sandy red earths with patchy scalds and flood channels, bearing diverse assemblage of small forbs, with very occasional *Triodia angusta* and shrubs. Characteristic species include *Centaurium erythraea*, *Sporobolus australasicus*, *Morgania glabra*, *Evolvulus alsinoides*, *Pterigeron bubakii*, *Malvastrum spicatum*, *Heliotropium undulatum*, *Nicotiana occidentalis* and *Pterocaulon sphacelatum*, the last five being denser and taller in floodout channels to the virtual exclusion of other species.

8. Salt flats

Limited areas near mouths of intermittent sandy watercourses, rendered salty by seawater percolation and salt spray deposition. Halophytes and succulents: *Halosarcia indica* ssp. *leiostachya*, *H. halocnemoides*, *Sclerolaena spinosa*, *Neobassia astrocarpa*, *Threlkeldia diffusa*, *Frankenia pauciflora*.

9. Disturbed areas

(a) road verges, well sites, etc. Characteristic species (all native): *Diplopeltis eriocarpa*, *Trichodesma zeylanicum*, *Cymbopogon procerus*, *C. ambiguus*, *Heliotropium undulatum*, *Adriana tomentosa*, *Tephrosia*

rosea, *Cassia notabilis*, *Pterigeron bubakii*, *Petalostyles labicheoides*. This secondary cover is denser in *T. angusta* lowlands, where all the above species are present, than on *T. wiseana* uplands where *Cymbopogon* is common along verges but the other species are much sparser.

(b) WAPET camp and offices: lawn of introduced *Cenchrus ciliaris* and *Cynodon dactylon* at camp, and planted trees of the introduced *Eucalyptus canaldulensis*, *E. torquata*, and *E. gouphocephala* in addition to planted natives such as *E. patellaris*, *Erythrina vespertilio* and *Pittosporum phylliraeoides*.

(c) disturbance in coastal assemblages is minimal, and floristics approximate those of surrounding areas.

Relation to substrate.

As indicated in the section above, each main vegetation unit is associated with a particular substrate, distinguishable on the basis of topography, texture and salinity. Results presented below show that there are also differences in pH and fertility, as measured by total nitrogen and extractable phosphorus content. (Total P was also measured for 7 samples, and the proportion extractable/total P found to be remarkably constant, with a mean of 0.162 and standard error 0.011). Comparison of the soils from different substrate units is hindered by variation with topography and depth within some units; in particular, the variation in weathering and soil formation on limestone areas, and the ridge sequences in the calcareous coastal sands. These were checked as follows.

Soils from two bulldozed exposures under *Triodia wiseana* (profiles A, B), and shallow soils from three additional limestone ridges are compared in Table 2. Sample C represents material from under a limestone slab on the northern ridge of transect 1; sample D the thin layer of blown sand covering the

Table 2

Triodia wiseana soil profiles: pH, total nitrogen, and extractable phosphorus

Profile	Depth m	Soil type	pH	Total N ppm	extr. P ppm
A	0.05	dark humic topsoil	7.25	570	289
A	1.3	interstitial material	7.79	690	407
A	1.5	red homog. subsoil	7.80	550	354
B	0.05	topsoil	7.60	500	190
B	1.2	rubble "subsoil"	7.73	620	470
B	1.2	rubble "subsoil"	7.85	490	505
C	0.10	dk. red-brn sandy loam	7.50	2 200	180
D	0.05	blown sand on limestone	7.75	160	273
E	0.05	skeletal soil between limestone blocks	7.18	1 100	80

limestone ridge at the inland end of transect 4, under *T. wiseana* and *T. pungens*; and sample E the detrital soil between limestone blocks on the high western Trealla limestone plateau, in an area of *Triodia wiseana* and *Acacia pyrifolia*. Overall, the shallow "topsoils" have significantly lower extractable phosphorus than the deeper "subsoil" materials from between or below massive shattered limestone blocks or coarse limestone rubble ($p < 0.01$). The high plateau sample (E) has lower extractable phosphorus content than any other island soil except the flood-out-flat clayey sand, and is slightly less alkaline than

the other limestone ridge soils. Ridge topsoils C and E have relatively high nitrogen contents, but not the dark humic topsoils from profiles A and B; sample C contains detrital material from an ant nest, and perhaps also sample E. There is a gradual decrease in pH inland across the white calcareous ridges of transect 3 (Table 3), and the strandline sand is low in total N, but there are no significant differences in total N or extractable P between the ridges.

Table 3

Dune sands: pH, total nitrogen and extractable phosphorus. Each value is the mean of three samples.

Location	Soil type	pH	total N ppm	extr. P ppm
Transect 3, above strandline	white calc. sand	8.88	100	337
Transect 3, 25 m inland	white calc. sand	8.50	130	437
Transect 3, 100 m inland	cream calc. sand	8.57	170	343
Transect 3, 160 m inland	pink calc. sand	8.41	160	405
Transect 3, 250 m inland	pink calc. sand	8.27	160	312
Bandicoot Bay neck, high dune	white calc. sand	8.70	150	584

Table 4

Soil pH and fertility of main substrate units; means (m) and standard deviations (s). N and P units are ppm.

Unit	n	pH		total N		extr. P	
		m	s	m	s	m	s
floodout flat	2	7.63	.40	455	64	52	4
limestone topsoil	2	7.42	.25	535	50	240	70
limestone, subsoil	4	7.79	.05	588	87	434	67
limestone, rubble	2	7.71	.01	150	0	293	67
red sand	1	7.75	....	400	....	635	....
white sands	5	8.61	.18	142	28	421	100
salt flat	1	9.30	....	240	....	160	....

Overall differences between main substrate types are shown in Table 4. T-tests show that the mean pH of the white sands is significantly higher than that of the limestone soils ($p < 0.001$) and significantly less than that of the salt flat ($p < 0.001$); the mean pH of the floodout flat differs significantly only from that of the salt flat. Mean N content of the white calcareous sands is significantly less than that of the salt flat ($p < 0.05$), red sand ($p < 0.001$), and limestone ($p < 0.001$); sample numbers are insufficient to show whether the salt flat N is significantly lower than that of the floodout flat. The limestone areas have highest soil N. Differences in extractable P are not statistically significant save for the low levels in the floodout soils.

Comparisons between soils occupied by different *Triodia* species are hampered by the variety of substrates occupied by each in mixed or marginal communities. *Triodia angusta* grows on both valley soils and coastal white sands. *T. pungens* is generally confined to red or pink sands but these range from the deep red sands at the northern end of transect 3 to the shallower red sands over limestone in the northern *Triodia* mosaic (Fig. 4) and the extremely thin cover of windblown red sand on the limestone ridge in transect 4. The range of variation in *T. wiseana* soils has already been described.

In conclusion, the soil analyses performed are sufficient to show that differences in soil pH and fertility parallel textural differences between major substrate units in some cases but not all. Considerably more detailed study would be required to establish patterns between subunits.

It was not possible to study the factors controlling shrub distribution (Figs. 4 and 5) in any detail, but the pattern for those associated with *T. wiseana* appears to be as follows. The highest western and northern regions with a greater percentage cover of limestone caprock have no shrubs or trees other than *Ficus platypoda*, occasional *Pittosporum phylliraeoides* and a single stand of *Eucalyptus patellaris*. Remaining areas tend to carry *Acacia pyrifolia* on the highest and most open ridges with caprock, *Cassia pruinosa* on similar but more restricted areas, and *Codonocarpus cotinifolius*, *Grevillea pyramidalis*, *Melaleuca cardiophylla*, *Acacia bivenosa* and *A. gregorii* on the broken limestone gravel of lower ridges and slopes.

Discussion

Effects of fire and grazing

As with *Triodia* hummock grasslands in general, the inland vegetation of Barrow Island burns readily but regenerates from seed, from rootstocks, or by epicaulal shoot production. The frequency of natural fires is unknown, since the island has been fired by man since its first European discovery.

It was burnt end-to-end by Captain Jarman in 1865, and a large fire burnt 75% of the island in 1961 (Cox 1977). Subsequently there have been a number of smaller fires. Burbidge and Main (1969) visited the island in November 1969 and compared the vegetation regenerating on areas burnt respectively 5 weeks, 3 months, 4 years and 7 years previously. In general, with modifications depending on substrate, the secondary succession after fire was started by *Triodia* spp., particularly *T. pungens*; shrubs such as *Petalostyles labicheoides*, *Acacia bivenosa*, *A. coriacea*, *A. gregorii*, *Stylobasium spathulatum*, *Adriana tomentosa* and *Corchorus parviflorus*, which regenerate from the rootstocks; and herbs of disturbed ground such as *Trichodesma zeylanicum* and *Heliotropium ovalifolium*. The additional species *Codonocarpus cotinifolius*, *Diplopeltis eriocarpa*, *Trinifetta appendiculata*, *Hannafordia quadrivalvis*, *Cynanchum floribundum*, *Clerodendrum tomentosum*, *Scaevola emminghamii*, *Olearia axillaris* and *Pterocaulon sphacelatum* were recorded only in the oldest burnt area.

In contrast to the rapid regeneration of burnt vegetation, areas where plant cover (and topsoil) were removed mechanically during the early phases of island utilisation have revegetated very slowly, if at all. Cleared areas forming part of the WAPET regeneration program, where the subsoil is ripped, the topsoil replaced, and wet-season flood erosion prevented, have regenerated more rapidly. They are seeded naturally, initially by herbs such as *Heliotropium ovalifolium* and *H. undulatum*, *Paspalum tabulatum*, *Pterigeron bubakii* and *P. macrocephalus*, *Trichodesma zeylanicum*, *Solanum diversiflorum*, *S. lasiophyllum*, *Chamaesyce* spp., *Pterocaulon sphacelatum* and *Chrysogonum trichodesmoides*, and shrubs such as *Diplopeltis eriocarpa*,

Stylobasium spathulatum, *Adriana tomentosa*, *Tephrosia rosea*, *Petalostyles labicheoides*, *Indigofera monophylla*, *Corchorus parviflorus* and *Cassia notabilis*. This colonising vegetation is subsequently replaced by *Triodia angusta*.

Plants regenerating after fire or clearance are grazed preferentially by the island's various marsupials and rodents (Butler 1970). Whilst the hare wallabies, *Lagorchestes conspicillatus conspicillatus*, eat mainly *Triodia* spp., the biggidas, *Macropus robustus isabellinus*, concentrate opportunistically on smaller forbs and for this reason are generally most abundant on floodout flats after rain. They are also common in the hummock grasslands, however, eating *Triodia* flowering heads or young leaves during dry periods. Their selective grazing probably accounts for the close association of, e.g. *Pittosporum phylliraeoides* and *Jasminum calcareum* with clumps of *Ficus platypoda*; seedlings germinating outside the fig clumps are eaten, and only those protected or concealed can reach maturity. Selective grazing probably also excludes a number of species from Barrow Island. The most conspicuous of these is *Ptilotus exaltatus*, which is abundant on neighbouring islands, such as Double Island and the Lowendal Islands, that are too small to support macropod populations. The same may apply to a number of species which, though found on Barrow Island, are much less common there than on the smaller islets; *Sesuvium portulacastrum*, *Tribulus terrestris*, *Atriplex semilunaris*, *Setaria dielsii*, *Commelina ensifolia*, *Iponoea pescaprae*, *Indigofera trita*, *Portulaca intrateranea* and *P. pilosa*, though dietary studies are as yet inadequate to assess the grazing pressure on these species, and the greater exposure and presence of seabird colonies on the islets may also be significant.

The plant communities as animal habitats

The main vegetation types listed earlier represent distinct habitat types for mammals (Butler 1970) and birds (Sedgwick 1976), but the subtypes do not seem to be significant. The low *Triodia* hummocks (< 400 mm) on the western side of the island are a poorer habitat for birds than the taller *Triodia* and associated shrubs to the east, but the *Ficus*, *Erythrina* and *Eucalyptus* trees are apparently of little significance (Sedgwick 1979). Fore-dune areas, mangroves and coastal headlands are important nest sites for the bar-shouldered dove and osprey. Smith (1976) divided the island's 38 reptile species into those confined to rocky areas, those confined to sands, and those found on both. Butler (1970) gave more detailed reptile habitat notes. Perry (1972) found that of the island's 25 termite species, 20 were grass harvesters found in the various *Triodia* habitats, and 5 were wood eaters occupying old mangrove logs. No termites were present in the coastal fore-dunes.

Floristic relations with the mainland

Different elements of the Barrow Island flora have different origins. Most species occupy similar habitats on island and mainland (cf. Sauer 1965). *Canavalia maritima*, *Capparis spinosa*, *Avicennia marina*, *Iponoea pescaprae*, *Cassytha filiformis*, *Sporobolus virginicus*, *Sesuvium portulacastrum*, *Chamaesyce atoto* and *Salsola kali* are part of the cosmopolitan seaborne Indo-Malayan strand flora

(cf. Schimper 1891). Of the Australian species, *Spinifex longifolius*, *Euphorbia tannensis* ssp. *eremophila*, *Chamaesyce australis*, *Tribulus* spp., *Tinospora smilacina* and *Myoporum acuminatum* are widespread along tropical Australian coasts, and *Olearia axillaris* and *Scaevola crassifolia* are widespread on the southern temperate coastal sands.

A large element of the Barrow Island flora is Eremaean (Gardner 1944, Burbidge 1960), species such as *Crotalaria novae-hollandiae*, *Cynanchum floribundum*, *Enchylaena tomentosa*, *Haloragis gossei*, *Petalostyles labicheoides*, *Portulaca oleracea*, *Ptilotus obovatus*, *Rhagodia obovata*, *Santalum lanceolatum*, *Sarcostemma australe*, *Sida corrugata*, *Sida fibulifera*, *Themeda australis*, *Trichodesma zeyanicum*, *Triodia pungens* and *Triraphis mollis* being widespread in the arid zone in a range of habitats.

Finally, several naturalised or adventive alien plants have been recorded on Barrow Island. *Solanum nigrum*, *Cryptostemma calceudila*, and a *Sonchus* sp. have reached the island but were eradicated. There is a single plant of *Acacia grashyi* at the WAPET camp, possibly introduced by barshouldered doves in the mid seventies. In addition, *Cenchrus ciliaris* and *Cynodon dactylon* have been introduced as lawn grasses but have not spread, and a few introduced eucalypt species have been planted around the WAPET camp and offices.

Barrow Island is separated from the mainland to the southeast by a channel 12 m deep, bordered by shoals and islands. Hence, given the Holocene sealevel history outlined by Thom and Chappell (1978), the island would have been isolated from the mainland between 7500 and 8000 BP. Since this time, gene flow between island and mainland has been negligible for terrestrial animals and probably low for plants. Barrow Island has endemic races of four mammals, and an endemic form of a fifth (Butler 1970), and at least five of the reptiles differ from mainland populations (Smith 1976). There have been no taxonomic studies of possible endemic forms in Barrow Island plant populations: Serventy and Marshall (1974) considered that Barrow Island *Lechenaultia divaricata* specimens had larger flowers than Central Australian ones, and peculiarities in size or succulence were noted for a few species during the present study, but both succulence and flower size may respond directly to rainfall, and Serventy and Marshall's visit in 1958 was preceded by good rains. Plants of *Nicotiana occidentalis*, *Chamaesyce australis*, *Calandrinia balonensis* and *Portulaca intraterranea* on the smaller islets are more succulent than those on Barrow Island itself; this could be due to the greater salinity, lower grazing pressure, or higher phosphorus input from seabird guano on the smaller islets.

Additional factors influencing plant distribution

Some coastal vegetation types are apparently modified by exposure to salt-laden winds. Limestone headlands on the Barrow Island coast, and small limestone islets offshore, bear *Triodia angusta* or *T. pungens*, though *T. wiseana* is the dominant species on inland limestones. This substitution is

particularly evident in more exposed sites where the *Triodia* hummocks often show evidence of wind and salt-pruning, growing in approximately shore-parallel lines whose dead and partially eroded upwind edges shield the living material on the island side. On Barrow Island this substitution could be accounted for in terms of substrate control in those cases where the headlands are covered thinly by windblown sands, but such an explanation does not hold on other headlands or on the islands, and salt exposure therefore seems a more likely reason.

Seabird nesting colonies are more significant to the vegetation on the smaller islets than on Barrow Island itself, though even on Barrow Island osprey and sea-eagle nests are often surrounded by a narrow ring of 'weedy' species such as *Salsola kali* and *Nicotiana occidentalis*. Small rock islands with tern nesting sites (e.g. Pasco Island, Prince Island) are often densely covered by *Salsola kali*, *Setaria dielsii*, *Amaranthus viridis*, *Nicotiana* spp. and *Cleome viscosa*, probably in response to increased soil nitrogen and phosphorus. Cormorant colonies, in contrast, remain largely denuded for several years after use, one on a small Lowendal islet containing only dead *Pittosporum phylliraeoides*, separated by a marginal ring of partly dead specimens from the healthy trees outside the colony. Cormorant colonies are generally at the outer limits of vegetation on these small rocky islands and the plants are already under stress.

The importance of herbivorous insects other than termites is unknown except in a few cases. The most conspicuous of these is the consumption of *Capparis spinosa* by larvae of the Caper White butterfly, which feed and pupate almost exclusively on this plant, though *Boerhavia* seems to be attacked in the absence or complete defoliation of *Capparis*. Such defoliation is particularly severe on the small off-shore islets.

It is possible that dynamic successional factors are as important as substrate in controlling the relative distributions of *Triodia angusta* and *T. pungens* in some areas. River valleys bear *T. angusta* and the large red sand flats largely *T. pungens*. On the coasts a narrow belt of *T. angusta* on partly stabilised cream sands separates the *Spinifex* assemblage of the mobile white foredunes from *T. pungens* on the stabilised inland dune slopes and red sands behind. Similarly, the mosaic of *T. angusta*, *T. pungens* and *T. wiseana* in the northern quarter of the island reflects a substrate mosaic. Small-scale *Triodia* pattern in the coastal complexes, however, could be accounted for only by a fine balance of substrate type, hydrology and exposure, or perhaps by the interaction of substrate factors with dynamic factors such as drought or fire. This requires further investigation.

Conclusions

The dominant vegetation on Barrow Island is *Triodia* hummock grassland, ringed by a complex of coastal vegetation types and broken in places by floodout flats. In all, nine vegetation units comprising 29 subunits were recognised and the main

units mapped and described. Actual ground vegetation patterns are of course more complex than this hierarchical classification, but it is believed to be an accurate and useful descriptive system which represents a considerable advance over earlier studies. The island's flora is a subset of the local mainland flora and comprises coastal elements, notably one derived from the Indo-Malayan strandline flora, and inland elements derived from the Australian Eremaean. The distribution of the island's main vegetation types is controlled primarily by substrate, including soil modification by calcium carbonate solution and redeposition, but fire, grazing and salt-wind exposure are also involved.

Recent and continuing anthropogenic vegetation modification has produced a disjunct "disturbed ground" unit, composed entirely of native plants, which succeeds in time to *Triodia angusta* hummock grassland. Where disturbance occurs in the *T. wiseana* limestone uplands, replacement by *T. angusta* is likely to be permanent, but to date this appears to be the only permanent vegetation modification caused by oil extraction and associated activities, and the small relative changes in the areas of the two habitat types are unlikely to have influenced the fauna. This state of affairs, however, is contingent upon current management practices: namely, restricting the anthropogenically disturbed area in any given terrain unit at any given time to less than that proportion of its total area which is likely to be disturbed by natural agents such as fire or cyclones; maintaining the populations of grazing macropods within their original bounds; and enhancing regrowth by ripping, topsoil replacement and flood control. Similarly, the continued absence of alien plants other than those planted around the camp and offices is contingent upon the quarantine constraints on incoming materials and people; the absence of seed-dispersing stock; the maintenance of high marsupial populations, which eat the introduced species; and continual active checks and eradication of any aliens which reach the island.

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Appendix 1

Key

[†] Collected by RCB during October 1980 and held at Herbarium Australiense.

* Collected by W. H. Butler previously and held in Barrow Island Herbarium. A total of 213 species are supported by voucher specimens. The remaining species are no longer traceable to voucher specimens, and some at least are likely to be misidentifications.

¹ new record for Barrow Island group.

² a single plant, now extinct.

³ well-watered hollows only.

⁴ in island's only brackish waterhole.

⁵ only recorded from small islands around Barrow Island.

⁶ introduced species.

Habitats

- W *Triodia wiseana* assemblages of limestone uplands.
A *Triodia angusta* assemblages of valley fill and lowlands.
R red sands.
C coastal white sands.
B rocky coasts.
F floodout areas.
S salt flats.
M mangroves.
D disturbed ground, or planted specimens.

Collection Numbers

Collection numbers are those of RCB. Those in the first column are held by W. H. Butler (P.O. Box C1580, Perth). Those in the second column are held by the Herbarium Australiense.

Nomenclature

Plant names are as Green, J. W., 1981, *Census of the Vascular Plants of Western Australia*. publ. Dept. Agriculture, South Perth.

	Habitat	WHB No.	Herbarium Australiense No.
<i>Abutilon crispum</i>	RD		
†* <i>Abutilon exoniense</i>	RD	6681 6813 7033	6681 6686 6813 6817 6924 7009 7033
<i>Abutilon fraseri</i>	RD		
† <i>Abutilon leucopetalum</i> ¹	R	7232	7231
†* <i>Acacia bivenosa</i>	WARCFD	7210	6790 7210
†* <i>Acacia coriacea</i>	CR		6680 7246
†* <i>Acacia grasbyi</i>	D	6696	6696
†* <i>Acacia gregorii</i>	WA		6655
†* <i>Acacia pyrifolia</i>	W		6939
†* <i>Acacia victoriae</i>	FR	6952	6951 6952
†* <i>Acanthocarpus preissii</i>	WR	6784	6784
†* <i>Adriana tomentosa</i>	D	6763	6763
<i>Alternanthera</i> sp.			
<i>Amaranthus pallidiflorus</i>			
† <i>Amaranthus viridis</i> ³	CB	6821 6961	6683 6836 6884 6961 6962
<i>Arctotheca calendula</i> ⁶	D		
<i>Aristida browniana</i>			
†* <i>Aristida contorta</i>	R	6910	6910
† <i>Atalaya hemiglaucula</i> ¹	WR	6862	6862 6866
† <i>Atriplex isatidea</i>	C		6742
†* <i>Atriplex semilunaris</i>	CB	7043 7077	7044 7078 7080
†* <i>Avicennia marina</i>	M		
<i>*Boerhavia chinensis</i>	CBR		
†* <i>Boerhavia diffusa</i>	CBR	6601	6625 6880 7059
† <i>Boerhavia repandra</i>	CB		6645 6650 7011
† <i>Bonania rosea</i>	R	6916 6932	6603 6664 6673 6917 6936
† <i>Bothriochloa bladhii</i> ¹	W	6895	6895
† <i>Bulbostylis barbata</i> ¹	C	7203	7203
† <i>Calandrinia balonensis</i>			
†* <i>Calandrinia polyandra</i>	WA	6746 6815	6746 6815
†* <i>Canavalia rosea</i>	CB		6879
†* <i>Capparis spinosa</i>	WB		6798
† <i>Capparis</i> sp. ^{1, 2} (RB 7155)	B	7155	7155
†* <i>Cassia glutinosa</i>	WD		
†* <i>Cassia notabilis</i>	WRD	6658	6658 6931
† <i>Cassia oligophylla</i>	W		
†* <i>Cassia pruinosa</i>	W	6635 6937	6635 6640 6661 6937
<i>Cassia venusta</i>			
† <i>Cassytha filiformis</i> ¹	CB	7050 7102	7050 7051 7102
†* <i>Cenchrus ciliaris</i> ⁶	D		
† <i>Centaureum erythraea</i> ¹	F	6695 6719	6695 6719
†* <i>Centipeda miniata</i>	F	6805	6805 6726 6765
† <i>Chamaesyce atoto</i>	C	6688 6903 7092	6688 6826 6901 6902 6904 6956 7092 7094
† <i>Chamaesyce</i> sp. aff. <i>atata</i>	WCB	6794 7148	6841 6923 7079 7148 7159
†* <i>Chamaesyce australis</i>	WCB	6756	6731 6831 6833
† <i>Chamaesyce myrtilloides</i>	C	6688 7083 7093	6832 6690 7062 7081 7083 7116
†* <i>Chenopodium carinatum</i>	RCD	6769	6624 6752 6827 6840
†* <i>Chrysogonum trichodesmoides</i>	WRD	6745	6745
†* <i>Chrysopogon fallax</i>	ARB		
†* <i>Cleome viscosa</i>	BD	6700	6700
†* <i>Cleradendrum tomentosum</i>	AR	6928	6615 6628 6643 6928 7220
†* <i>Clinanthus formosus</i>	AR		
†* <i>Codonocarpus cotinifolius</i>	AD	6941	6941
†* <i>Commelina ensifolia</i>	WB		

	Habitat	WHB No.	Herbarium Australiense No.
<i>Commelina lanceolata</i>			
† <i>Convolvulus</i> sp. ¹ (RB 7250)	B	7250	7250
†* <i>Corchorus parviflorus</i>	WARBD	7132....	7132
† <i>Corchorus sidioides</i> ¹	WARB	6938	6732 6751 6793
†* <i>Corchorus walcottii</i>	AD	6638	6623 6647 6734 6870
†* <i>Cordia subcordata</i>	C		7221
† <i>Corynotheeca acanthoclada</i> ¹ ..	W	7202....	7202 7222
† <i>Crotolaria medicaginea</i> ^{1, 5} ..	B	7258....	7258
* <i>Crotolaria novae-hollandiae</i>	CD		
<i>Crotolaria trifoliolatum</i> ..			
<i>Cuscuta australis</i>			
† <i>Cymbopogon ambiguus</i>	WD		6760 6947
<i>Cymbopogon bombycinus</i>			
†* <i>Cymbopogon procerus</i> ..	WD	6947....	6946 6947 6760
†* <i>Cynanchum floribundum</i> ..	CR	6654	6662
† <i>Cynodon dactylon</i> ⁶	D	6740 6798	6740 6741 6749 6798 6848
†* <i>Cyperus cunninghamii</i> ¹ ..	WB	6605 6627 ..	6627 6651 6858 6943
† <i>Cyperus squarrosus</i> ..	F	6737....	6737
†* <i>Dactyloctenium radicans</i> ..	BD	7128....	7128
†* <i>Dichantherium affine</i>	F	6714	6705 6714
† <i>Didcladanthra forrestii</i> ^{1, 5} ..	B	7129 7130 7142	7129 7130 7131
† <i>Didcladanthra</i> sp. (RB 6863) ..	W	6863....	6863
†* <i>Diplopeltis eriocarpa</i>	WAD		6744
†* <i>Dodonaea lanceolata</i>	WA	6613 ..	6613
<i>Dolichandrone heterophylla</i>			
* <i>Duboisia hopwoodii</i>			
† <i>Dysphania inflata</i> ¹	FB		
† <i>Dysphania plantaginella</i> ..	FB	6706....	6706 6685
†* <i>Dysphania rhadinostachya</i> ..	RCD	6721....	6753
† <i>Euchylaena tomentosa</i> ..	SM	6960 7234	6960 7042
<i>Enneapogon caeruleus</i> ..			
†* <i>Enneapogon oblongus</i>	WFB	6891 7226	6800 6801 6891 6968 7225
† <i>Enneapogon polyphyllus</i> ¹ ..	FB	7242 ..	7230 7242
†* <i>Eragrostis basedowii</i>	FB		
† <i>Eragrostis cunningii</i> ¹	F		6725
†* <i>Eragrostis dielsii</i>	FB	7261....	7031 7261 7262
†* <i>Eragrostis falcata</i>	F	7058....	7056 7057
†* <i>Eragrostis xerophila</i>	FB		
†* <i>Eriachne flaccida</i>	F	6737....	6737 6810
†* <i>Eriachne mucronata</i>	WA		
†* <i>Erythrina vespertilio</i>	A		
* <i>Eucalyptus camaldulensis</i> ⁶	D		
* <i>Eucalyptus gomphocephala</i> ⁶ ..	D		
†* <i>Eucalyptus patellaris</i>	WA		
* <i>Eucalyptus torquata</i> ⁶	D		
†* <i>Eulalia fulva</i>	AR		
†* <i>Euphorbia iannensis</i> ssp. <i>eremophila</i>	RC ..	7001 7002 ..	6837 7001 7002 7003 7005 7012 7098 7099 7111
† <i>Evolvulus alsinoides</i> ..	F	7237....	7238
† <i>Ficus opposita</i> ¹	W	6802 ..	6802
†* <i>Ficus platypoda</i>	W	6621 6776	6776 7022
† <i>Ficus</i> sp.	F		6616
* <i>Fimbristylis schultzei</i>	F		
†* <i>Flaveria australasica</i>	WCB	7068	6657
†* <i>Frankenia pauciflora</i>	BSM	6733 7060	6729 6733 6949 6950 7069
†* <i>Gnaphalium lateo-album</i>	WF		
†* <i>Gomphrena conferta</i>	SB	7029 7030	7030 7125
†* <i>Goodenia microptera</i>	WB	6896 ..	6785 6896 6921 7054
<i>Gossypium australe</i>			
†* <i>Gossypium robinsonii</i>	A	6940....	6940
† <i>Gnaphalium</i> sp.	RB	6652....	6652
†* <i>Grevillea pyramidalis</i>	W		
†* <i>Hakea suberea</i> ..	W		
†* <i>Haloragis gossei</i>	D	6712....	6712 6749
†* <i>Halosarcia halocnemoides</i>	SM	6780....	6772
†* <i>Halosarcia indica</i> ssp. <i>leiotachya</i>	SM ..	6781....	6773
†* <i>Hannafordia quadrivalvis</i> ..	WAR	6619 6626	6619 6626 6632
<i>Heliotropium conocarpum</i> ..			
<i>Heliotropium crispatum</i> ..			
<i>Heliotropium cunninghamii</i> ..			
†* <i>Heliotropium ovalifolium</i>	WARD	6611 6792	6618 6670 6771 6792
†* <i>Heliotropium undulatum</i> ..	WARD	6850 6867	6637 6689 6755
† <i>Heliotropium</i> sp. ¹ (RB 6866) ..			6866
† <i>Heliotropium</i> sp. ¹ (RB 7037)		7037....	7037 7090
<i>Hemichroa diandra</i>			
* <i>Hibiscus sturtii</i> var. <i>campylochamys</i>	W		
† <i>Indigofera boviparda</i> ¹	B		
† <i>Indigofera cobutea</i>	WF	6814....	6686 6814 7256
† <i>Indigofera emeaphylla</i> ..			
†* <i>Indigofera georgei</i>	WA		
†* <i>Indigofera linifolia</i>	AR	7013....	7014 7233
†* <i>Indigofera monophylla</i>	WAD	6877	6602 6612 6629 6639 6787
† <i>Indigofera trita</i> ¹	B	7036....	7036 7060 6914

	Habitat	WHB No.	Herbarium Australiense No.
† <i>Indigofera</i> sp. (RB 6723)			6723
* <i>Indigofera</i> sp.			
†* <i>Ipomoea brasiliensis</i>	C		
<i>Iseilema eremaeum</i>			
†* <i>Jasminum calcareum</i>	W	6739....	6739 6828 7153
† <i>Jasminum</i> sp. (RB 7144)		7145....	7144 7146
<i>Keraudrenia</i> sp.			
† <i>Launaea samentosa</i> ^{1, 5}	C	7117....	7118 7123
† <i>Lawrenzia</i> sp. (RB 7136)		7137 7147	7135 7136 7137 7147
<i>Lichenaultia divaricata</i>			
† <i>Lepidium</i> sp. (RB 7139)		7139....	7139 7140 7141
†* <i>Linonium salicorniaceum</i>	S	6778 7035	6676 6778 7034 7035
<i>Loranthus</i> sp. (Amyema? RB)			
† <i>Lotus australis</i> ¹	W	6881....	6881
†* <i>Mallotus uesophilus</i> ³	W	6897....	6857 6897
†* <i>Malvastrum americanum</i>	WAFBD	6709....	6607 6609 6610 6709 6959
† <i>Marsdenia cinerascens</i> ¹	B	6969	6967 6969
* <i>Marsilea</i> sp.	F		
†* <i>Melaleuca cardiophylla</i>	W	6922....	6922
†* <i>Melhania oblongifolia</i>	B	7133 7134 7157	6604 7073 7074 7075 7114 7120 7121 7126 7133 7134 7157 7263
* <i>Mimulus gracilis</i>	F		
†* <i>Morgantia glabra</i> ¹	F	6727....	6727 6809
†* <i>Mukia maderaspatana</i>	WD		6918
†* <i>Myoporum acuminatum</i>	RC	6929....	6641
†* <i>Neobassia astrocarpa</i>	SB	6740....	6722 6740 6873
†* <i>Nicotiana benthamiana</i> ³	WB	6856....	6856 6942 7267
†* <i>Nicotiana occidentalis</i>	WARCBD	6696....	6614 6691 6702 6812 6915
†* <i>Oldenlandia crouchiana</i>			
†* <i>Olearia axillaris</i>	C	6843....	6820 6855
* <i>Olearia revoluta</i>	C		
†* <i>Panicum australiense</i>	W	7158	7152
<i>Paspalidium clementii</i>			
<i>Paspalidium gracile</i>			
†* <i>Paspalidium tabulatum</i>	WRBF	6737 6768 6788 6912	6677 6764 6912 7028
†* <i>Passiflora foetida</i>	WB		
†* <i>Petalostylis labicheoides</i>	RD	6791	6759
†* <i>Phyllanthus maderaspatensis</i>	W	6899 7241	6899 6900 6905 6906 6935 7241
†* <i>Pittosporum phylliracoides</i>	W	6860	6865 6887 6894 7154
†* <i>Pluchea rubelliflora</i>	WRD	6854	6854 7206
†* <i>Pluchea squarrosa</i>	WRD	6911	6911
†* <i>Pluchea tetranthera</i>	WRD	6852 6953 6958	6852 6953 6958
†* <i>Plumbago zeylanica</i> ³	WB	6620	6620 6644
†* <i>Polycarpaea longiflora</i>	WRD		6631 6663
* <i>Polymeria ambigua</i>	WA		
<i>Polymeria calycina</i>			
<i>Portulaca australis</i>			
† <i>Portulaca intraterranea</i> ¹	B	7107 7207	7095 7106 7107 7208
<i>Portulaca oleracea</i>			
* <i>Portulaca pilosa</i>	B	7053 7255	7052 7088 7112 7225
†* <i>Psoralea lachnostachys</i>	ARD	6760....	6754 6762
†* <i>Psoralea leucantha</i>	WAD	6736	6642 6736
† <i>Pterigeron adscendens</i>	RD	7205....	7204 7205
†* <i>Pterigeron hubakii</i>	ARD	6698....	6684 6698 6717 6957
†* <i>Pterigeron decurrens</i>	RD		
†* <i>Pterigeron macrocephalus</i>	RD	7257....	7257
†* <i>Pterocaulon sphaerolatum</i>	RD		6796
<i>Pterocaulon sphaeranthoides</i>			
†* <i>Ptilotus clementii</i>	WAD	6682....	6861 6945
†* <i>Ptilotus exaltatus</i>	RB	7006....	7004 7032
* <i>Ptilotus fusiformis</i>	R		
†* <i>Ptilotus obovatus</i>	WAD	6804 6715	6606 6634 6697 6715 6876 6890
†* <i>Ptilotus villosiflorus</i>	C	6735....	6735
†* <i>Rhagodia dioica</i>	C		
†* <i>Rhagodia obovata</i>	C	7104....	6819 6830 7037 7091 7096 7097 7103 7104
* <i>Rhizophora stylosa</i> ²	M		
†* <i>Rhynchosia minima</i>	WB	6889 7151	6660 6825 6849 6908 6919 6920 7110 7122
†* <i>Ruellia primulacea</i>	WB	6885 6907	6885 7007 7008 7045 7046 7047 7048 7072
†* <i>Ruppia maritima</i> ⁴			6869 6972
†* <i>Salsola kali</i>	RCD		
† <i>Sanolus repens</i>	WB	6933 7259	6913 6933 7259 7260
<i>Santalum lanceolatum</i>			
†* <i>Santalum spicatum</i>	A	6864....	6864
†* <i>Sarcostemma australe</i>	WB		6782
† <i>Scaevola</i> sp. cf. <i>aemula</i>	D		6888
† <i>Scaevola crassifolia</i>	C	7100....	7100 7101
† <i>Scaevola cunninghamii</i>	WRCB	6608 6653 6666	6646 6653 6666 6785 6842
†* <i>Scaevola decipiens</i>	RF	6622....	6617 6622
* <i>Scaevola glandulifera</i>	WB		

	Habitat	WHB No.	Herbarium Australiense No.
<i>Scaevola globulifera</i>	WRCB		
* <i>Scaevola nitida</i>	C		
† <i>Scaevola spinescens</i>	RCB	6675 7015	6675 6678 7026 7063 7223
* <i>Scaevola</i> sp.			
* <i>Scirpus dissachanthus</i> ²	W		
<i>Scirpus marginatus</i>			
<i>Sclerolaena convexula</i>			
† <i>Sclerolaena spinosa</i>	CRBSM	6783	6711 6750 6770 6775 6777 6779 6871 7224 7268
* <i>Sclerolaena uniflora</i>			
<i>Sesbania hispidula</i>			
† <i>Sesuvium portulacastrum</i>	MB	6965	6965
† <i>Setaria dielsii</i>	CB	6963 7753	
* <i>Setaria verticillata</i>			6963 6964 7019 7020 7021 7023 7024 7113
† <i>Sida calyxhyena</i> ¹	C	7236	7235
† <i>Sida corngata</i>	WB	6875	7245 7143
† <i>Sida chinocarpa</i>	D	6853	6853
† <i>Sida fibulifera</i> ¹	RF	6701	6710
† <i>Solanum cleistogamum</i>	WB	6687 7228	6720 7227 7228 7239 7243
† <i>Solanum diversiflorum</i>	RD	6633	6633 6636 6713 6718
† <i>Solanum esuriale</i> ¹	B	7156	7138 7160
<i>Solanum horridum</i>			
† <i>Solanum lasiophyllum</i>	WARD	6738	6738
* <i>Solanum nigrum</i> ⁶	D		
† <i>Solanum phlomoides</i>			
<i>Solanum quadriloculatum</i>			
<i>Sonchus</i> sp. ⁴	D		
*† <i>Sorghum plumosum</i>	A	6716	6692 6808 7149
† <i>Spinifex longifolius</i>	C	6822	6822 6823
† <i>Sporobolus australasicus</i>	F	6704	6694 6699
† <i>Sporobolus virginicus</i>	MCB	6648 6693	6667 6708 7115
† <i>Stackhousia elata</i> ¹	D	6659	6730
<i>Stackhousia muricata</i>			
<i>Stemodia grossa</i>			
† <i>Stylobasium spatulatum</i>	AD	6703	6753
† <i>Swainsona kingii</i>	ABD	7086	7085 7086 7087
† <i>Swainsona pterostylis</i>	RCD	6656	6649 6665 6671
† <i>Synaptantha tilluacea</i>	RF	6874 7229	6874 7027 7061 7079 7229
† <i>Tephrosia eriocarpa</i>	WAD	6668	6668 6955
† <i>Tephrosia rosea</i>	WAD	6818	6818 6721 6789
<i>Themeda australis</i>			
† <i>Threlkeldia diffusa</i>	BSM	6954	6743 6872 6954 7018
† <i>Tinospora smilacina</i>	B		6859
<i>Tribulus occidentalis</i>	B		
† <i>Tribulus terrestris</i> ¹	B		7064 7065 7066
*† <i>Trichodesma zeylanicum</i>	WARCFD		6774
† <i>Triodia angusta</i>	A	6838	6708 6747 6971
† <i>Triodia pungens</i>	R		
† <i>Triodia wiseana</i>	W	6909	6757
† <i>Triumfetta appendiculata</i>	WA		6669
† <i>Triumfetta leptacantha</i>	WA	6807	6672
† <i>Triumfetta micracantha</i>	WA	6882	6797 6868 6882
† <i>Triraphis mollis</i>	B	6892 7082	6892 7067 7089 7254
† <i>Vittadinia hispidula</i>	R	6786	6786
* <i>Vittadinia</i> sp.			
† <i>Wahlenbergia</i> sp. ¹ (RB 6816)	F	6766	6766 6816
† <i>Waltheria indica</i>	B		

